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SEPARATION OF YTTRIUM FROM STRONTIUM BY HOLLOW FIBRE SUPPORTED LIQUID MEMBRANE CONTAINING DI(2-ETHYLHEXYL)PHOSPHORIC ACID

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ABSTRACT

Separation of Y(III) from Sr(II) was performed using the hollow fibre membrane contactor operated in a recirculation mode. The steady-state was established after ~5 h of operation and the maximum removal of Y(III) from the donor to the acceptor was achieved at the donor flow rate of 4.7 cm^3 min^{-1}. The investigated system showed promising results as a method which could be potentially applied for the preparation of ^{90}Sr/^{90}Y generator system.

INTRODUCTION

^{90}Sr is an ideal source of carrier-free ^{90}Y ($T_{1/2}$ = 64.1 h, $E_{\beta,max}$ = 2.3 MeV), which has suitable radionuclidic characteristics for the application in endoradiotherapy of malignant tumors. The separation of carrier-free ^{90}Y from ^{90}Sr might be achieved by a variety of physicochemical methods [1 - 4], among them is method based on the supported liquid membranes (SLMs).

SLM extraction is based on a three-phase system and involves simultaneous extraction and re-extraction. The pores of a microporous hydrophobic membrane are filled with the organic phase (extractant or liquid membrane) held by the action of capillary forces, while the feed (donor) and the stripping (acceptor) solutions are placed at the opposite sides of the membrane. SLM extraction is performed in a continuous-contact mass transfer devices – membrane contactors, designed as compact units using either flat sheet or hollow fibre (HF) hydrophobic membranes.

The purpose of the present study was to investigate SLM extraction of strontium and yttrium with di(2-ethylhexyl)phosphoric acid (DEHPA) as a carrier in a continuous HF contactor operated in a recirculated mode, with regard to the potential application of the applied system for the generation of carrier-free ^{90}Y from ^{90}Sr source. The influence of the time of extraction and the donor phase flow rate on the efficiency of separation of Y(III) from Sr(II) was observed.

EXPERIMENTAL

Separation of Y(III) from Sr(II) was carried out in the self-designed membrane contactor containing seven HF polypropylene membranes, ACCUREL 50/280 (Membrana GmbH, Wuppertal, Germany), enclosed in a glass shell. Experimental setup of a recirculating SLM extraction system is shown in Fig. 1. SLM extraction system consisted of a HF membrane contactor (C), two reservoirs for the donor and acceptor solutions (R1 and R2), two peristaltic pumps (P1 and P2) and magnetic stirrer (M).

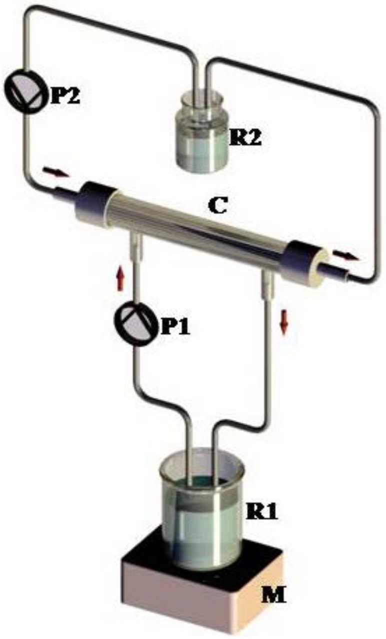

Figure 1. Experimental setup of a recirculating SLM extraction system.

HF membranes, with the effective length of 119 cm, were impregnated with 15% DEHPA in dodecane. The donor solution (5.5 mM Sr(II) and 0.2 mM Y(III)/0.1 M HCl), 25 cm^3, was fed along the shell side of the fibre and recirculated in a closed loop between the module and reservoir R1 using peristaltic pump P1. The flow rate of the donor phase, Q_D, was 0.8-4.7 cm^3 min^{-1}. The acceptor solution (3 M HCl), 4 cm^3, was pumped through the lumen of the HF using peristaltic pump P2 and recirculated between the module and reservoir R2. The flow rate of the acceptor, Q_A, was 0.8 cm^3 min^{-1}. The donor and acceptor solutions flowed co-currently within the module.

Strontium and yttrium concentrations in the donor and acceptor solutions were determined by ICP-OES, Spectroflame model B (Spectro Inc., MA, USA). The efficiency of Sr(II) and Y(III) mass transfer through the liquid membrane was evaluated using the following parameters: the removal efficiency, E_R, (represents the fraction of the respective metal ion removed from the donor phase), the extraction efficiency, E, (represents the fraction of the metal ion initially present in the donor phase that was found in the acceptor after extraction) and the memory effect, *M*, (the fraction of the respective metal ion captured in the organic phase).

RESULTS AND DISCUSSION

Fig. 1 shows time-dependent variations of the Y(III) concentration in the donor and acceptor phase reservoirs at five different donor flow rates. As can be seen, the concentration of Y(III) in the donor reservoir decreased significantly during the first 4 h of operation, and then gradually reached a plateau, whereas its concentration in the acceptor increased nearly in the same manner. The steady state was established after ~5 h of operation.

The lowest Y(III) concentration in the donor and the highest Y(III) concentration in the acceptor were achieved at the Q_D of 4.7 cm^3 min^{-1}. At the same Q_D, Sr(II) concentration in the donor was reduced by 8% compared to the initial Sr(II) concentration. Despite this fact, re-extraction of Sr(II) in the acceptor was practically negligible (< 0.03% of its initial concentration). The obtained results suggest that the applied system could be potentially applied as a generator of ^{90}Y for use in nuclear medicine.

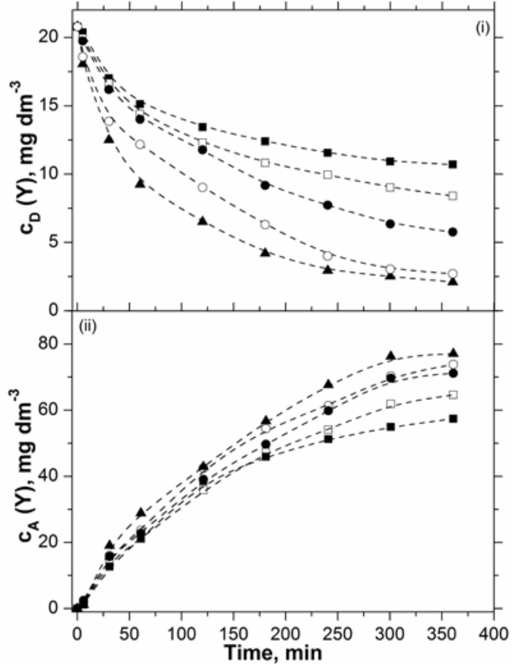

Figure 2. Time dependence of the Y(III) concentration in the donor (c_D) and acceptor (c_A) phase at different Q_D: (■) 0.8 cm^3 min^{-1}, (□) 1.6 cm^3 min^{-1}, (●) 2.4 cm^3 min^{-1}, (○) 3.2 cm^3 min^{-1}, (▲) 4.7 cm^3 min^{-1}. Q_A was 0.8 cm^3 min^{-1}.

The steady-state values of the extraction parameters (*E*, E_R and *M*) are presented in Table 1. It can be seen that the E_R of Y(III) increased significantly with increasing the Q_D from 0.8 to 3.2 cm^3 min^{-1}, but the effect was less pronounced with further increase in the Q_D. E of Y(III) was not such affected by increasing the Q_D, indicating that a portion of the extracted Y(III) remained in the organic phase. The reason for the suppressed re-extraction of Y(III) at higher Q_D could be the increased viscosity of the organic phase or insufficient contact area provided for the re-extraction.

Table 1. Efficiency parameters of Y(III) transport through SLM as a function of the donor flow rate.

Q_D, cm^3 min^{-1}	E_R, %	E, %	M, %
0.8	48.6	44.2	4.4
1.6	59.6	49.8	9.8
2.4	72.3	54.8	17.5
3.2	87.0	56.8	30.1
4.7	89.9	59.3	30.6

CONCLUSION

The obtained results indicated that the HF membrane contactor under recirculation mode of operation enabled efficient separation of Y(III) from Sr(II) at all investigated donor flow rates. The maximum removal of Y(III) (~60%) from the donor to the acceptor was achieved after 6 h of operation at the Q_D of 4.7 cm^3 min^{-1}. However, additional effort is needed to ensure lower degree of Y(III) accumulation in the organic phase.

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